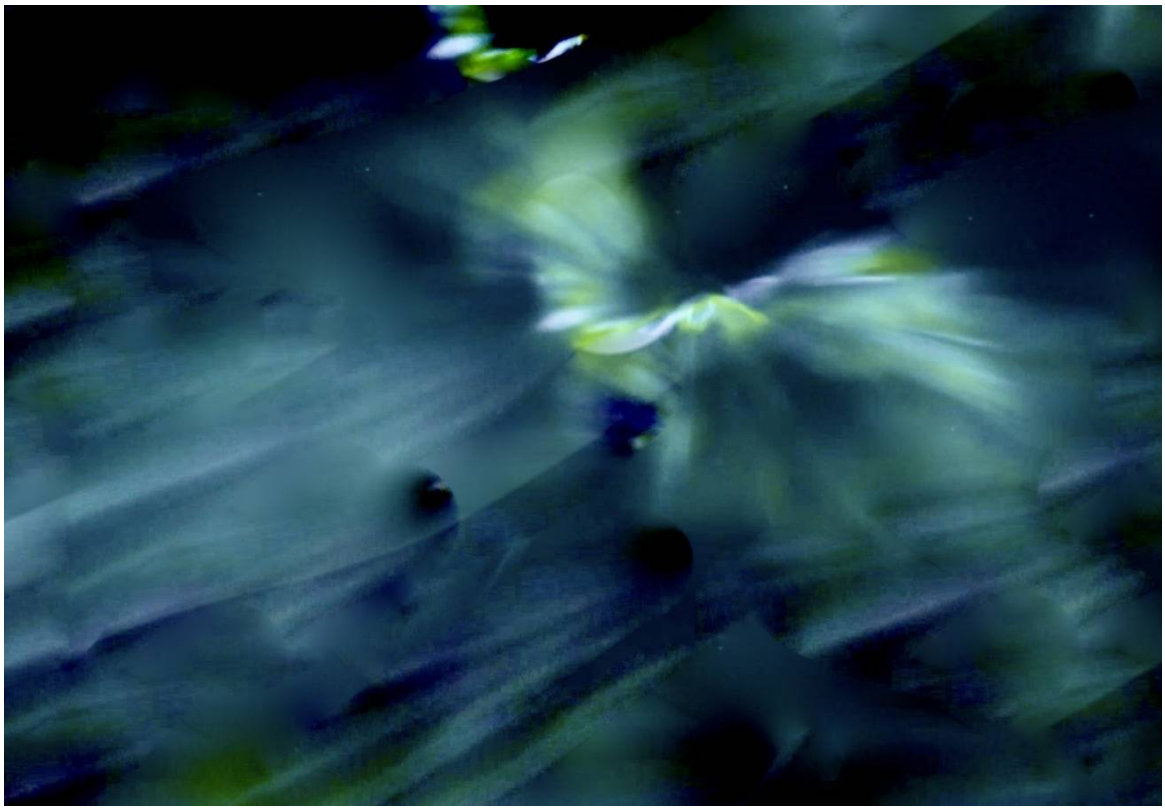

ALAN N. SHAPIRO 2024-08-05

BRAIN-COMPUTER INTERFACE

GENERICSCIENCE AI, BARIN, COMPUTER, CYBORG, INTERFACE

The digital-neurological or Brain-Computer Interface (BCI) is another key science fiction and "real" technology of the Fourth Industrial Revolution. BCIs can be interpreted as a "becoming cyborg" of humanity. One can distinguish between mainstream versus alternative/ transformative designs and implementations of the user applications to be based on BCI – the command-and-control cyborg versus the feminist-theory cyborg. Rethinking and reinvention of Donna Haraway's cyborg theory are possible in the BCI context. A BCI is a direct communication link between the neurological workings of the human brain, understood as electrical activity, and an external technological device which could be, for example, a robotic arm or leg; or a computer, digital network, or "smart home of the future." The BCI technology will have applications to help disabled people to gain greater functionality in

everyday life. This betterment with respect to disabilities can be in either cognitive or sensory-motoric areas. Practical uses could be a neural prothesis or the operation of a wheelchair. Distressing mental and emotional states can be diagnosed and therapeutically altered. BCIs will also have applications for the wider public in mass and personalized markets in many domains: healthcare, education, gaming, entertainment, shopping and advertising, security and identity authentication, and relations with robots. The digital-neurological interface might fundamentally change our interaction with computers: supplementing or replacing keyboard and mouse, the touchscreen, and the speech interface.

The distinction is made among non-invasive, partially invasive, and invasive BCIs. Research is proceeding at universities and in industry in all three categories. The non-invasive BCI builds on the technologies of the electroencephalography (EEG), magnetic resonance imaging (MRI), and functional magnetic resonance imaging (fMRI). EEGs are used to diagnose and monitor neurological conditions. Small metal disc electrodes are attached to the scalp. The EEG technology can be upgraded to BCIs. During an MRI procedure, electrodes from the outside obtain data from the electrical activity within the cerebral cortex. An fMRI measures brain activity by detecting changes in blood flows. The partially invasive approach extends electrocorticography – electrodes are placed on the exposed surface of the brain. Invasive BCIs involve neurological surgery to insert a microelectrode array close to actual brain tissue. Data and commands are then sent and received bidirectionally, resolved on a lower level of coding in the translation between bio-neurological signals and the electrical signals native to the microelectrodes of the implanted prosthesis. The cortical plasticity of the brain enables it to handle the signals from the BCI as if they were physiological impulses.

A 1973 academic paper by Jacques Vidal (“Toward Direct Brain-Computer Communication”) coined the term Brain-Computer Interface.96 After much testing on animals, the first neuro-prosthetic implants were made into humans in the 1990s. The computer science area of neural network Deep Learning AI has major relevance to the BCI knowledge field. In the step of “feature extraction” in the BCI processing flow, an analysis of the signal is carried out. Data gets extracted. The statistical and pattern-based methods of Deep Learning train a software to classify neural-activity thoughts as the user cogitates her intention to send a command to execute a task or performance on or by the external device.

In 2014, Nathan Copeland, who had a severe spinal cord injury resulting from a car crash, became the first person to have microelectrodes implanted in both his sensory and motor cortices. Copeland said that he was motivated to take this pioneering step by his love of science fiction. He stated: “Luke Skywalker loses his hand then basically the next day he’s got a robot one and it’s working fine. We must get to that point. To do that, someone must start it.”97 Copeland’s YouTube playlist is called “My Cyborg Adventure.” With his implant, he was able to send and receive signals to and from his robotic arm, to control its movements and handling of objects, and to feel touching sensations with the artificial limb.

Matthew Nagle, who had suffered a spinal cord injury from a knife fight, had the BrainGate BCI implanted in his motor cortex in 2004. He was able to control a computer cursor, play computer games like Pong, to send and receive e-mails, and operate his TV. Nagle could remote-control a prosthetic arm enough to open and close the grasp of the hand.

There are reasonable arguments both for and against non-invasive versus invasive BCIs. The non-invasive technology has the obvious advantage of not requiring neural surgery. Yet it does not work as well as the invasive variety, largely due to the distance of the sensor from the actual neurons. The signal from the neuronal electrical field can get weakened or distorted by the fluids and tissues immediately surrounding the source neurons.

There is also some concern that invasive BCIs might be associated with degenerative neurological disease. An additional problem is that scar tissue grows over time around the implanted electrode, causing it to become effectively non-functional after a few years. This difficulty might get solved if progress is made towards increasing the surface area of the electrode without increasing its geometric volume. Higher spatial resolution will also provide more precision indications about the signals.

The sequence of operation of the Brain-Computer Interface consists of four stages: signal acquisition, feature extraction, feature translation, and device output. The acquired signals get digitalized. They are then sent to the next algorithmic sub-system, which formats the data into a form that can be converted to commands that carry out the user's intentions in the manoeuvring of the external device. The device sends feedback as a return value.

Ethical concerns around BCIs include questions of privacy violation, personal identity theft, and the validity of informed consent. Much of the privacy worries relate to confusion regarding whether the connection will be one-way or in both directions. Assuming that the link is unidirectional from brain to computer, there is little danger of dystopian mind control.

Together with eight partners, billionaire entrepreneur Elon Musk founded the neurotechnology company Neuralink in 2016. The mission of the company is to devise Brain-Computer Interfaces that would provide the underlying system level for applications for both people with neurological impairments and for general commercial and consumer sales. In 2019, Neuralink announced its project of developing a "sewing machine like" technology to implant thin strings of electrodes into the animal or human brain. The company has demonstrated systems that read potential nerve action impulses from lab rats and monkeys. In February 2022, it was reported that 18 of 23 monkeys who had Neuralink devices implanted into their skulls had died. Trials on humans were postponed indefinitely.

The scope and range of potential applications of BCIs are mind-boggling. Given the coming to fruition of ubiquitous wireless communication, one can imagine the realization of a telekinetic capability to control any devices in the physical world merely with one's thoughts. The 1956 science fiction film Forbidden Planet shows a world that runs on a secret underground infrastructure and power source of super-technology, stretching for hundreds of kilometres, built by a defunct advanced techno-scientific society. The ancient civilization disappeared due to its hubris of designing a system of total Virtual Reality control over the physical world, which instead ended in total self-destruction.

From the point of view of cyborg theory, one can say that the technology of BCIs has the potential of both/either great good and/or evil. Such an extreme technology would need a corresponding transdisciplinary worldview or political philosophy of a good society as an encompassing framework within which to think through and guide its benevolent use. This pragmatic-utopian perspective is perhaps something like Haraway's stated commitment to

socialist feminism, with somewhat more of an emphasis on the positive value of democracy, and yes, even of capitalism. There is no comprehensive utopian political theory – synthesizing the best aspects of many previous theories – that exists in the world today.

taken from here: https://www.alan-shapiro.com/brain-computer-interface/

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